

Quasars around the Seyfert Galaxy NGC3516

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Received _____; accepted _____

ABSTRACT

We report redshift measurements of 5 X-ray emitting blue stellar objects (BSO's) located less than 12 arc min from the X-ray Seyfert galaxy, NGC 3516. We find these quasars to be distributed along the minor axis of the galaxy and to show a very good correlation between their redshift and their angular distance from NGC 3516. Moreover the redshifts of these 5 quasars are: 0.33, 0.69, 0.93, 1.40 and 2.10 which are very near the peaks of the redshift periodicity distribution (i.e. $z = 0.3, 0.6, 0.96, 1.41$ and 1.96). All these observed properties strikingly confirm, around this single example of a Seyfert, the composite picture derived from previous physical associations of quasars with low redshift, active galaxies.

Subject headings: quasars: general – Seyfert galaxies

Recently H.-D. Radecke (1997) has presented evidence that there is a significant (minimum of 7.4 sigma) excess of bright X-ray sources around a nearly complete sample of Seyfert galaxies. Arp (1997) had inspected each individual X-ray map of 24 Seyfert galaxies with an apparent magnitude between $8.04 \leq B_T^{0,i} \leq 12.90$ mag. and found that on Schmidt Survey plates most of these excess X-ray sources are identified with blue stellar objects (BSO). These X-ray emitting BSO's generally show pairing and alignment configurations cross the central Seyfert galaxies.

We have started a program to obtain the optical spectra of these X-ray emitting BSO's. Herewith we present our result in the field NGC3516. NGC3516 is a strong X-ray Seyfert galaxy, with apparent magnitude $V=12.40$ and redshift $z=0.009$. In Radecke's Seyfert sample, NGC3516 belongs to the faintest and most distant category. X-ray sources

associated with this galaxy would therefore be as bright as 6×10^{40} erg s $^{-1}$, which is about ~ 300 times brighter than any galactic X-ray sources. There are 5 BSO objects listed in Table 3 of Arp’s paper, these objects are located in the region $\theta < 12'$ and aligned NW–SE across NGC3516. (see Fig.1 in which these BSO are identified by their X-ray count rate $C = \text{cts}\cdot\text{ks}^{-1}$ value).

EDITOR: PLACE FIGURE 1 HERE.

We obtained the spectra of the 5 BSO’s on April 4–5, 1997 using the 2.16m telescope at Xinlong Station, Beijing Astronomical Observatory. An OMR spectrograph was attached at the Cassegrain focus. A TEK1024 \times 1024 CCD served as detector at a resolution of 400Å/mm. The coverage of the spectra was from 3700 to 8000Å. Integration time for each spectrum was 3600s. Fe/Ar lamp was used for wavelength calibration and Feige34 and Hz44 as flux standard stars. The data were reduced with the IRAF package. One of the objects Q1107+7232 ($C=7.1$) is already listed in the Hewitt-Burbidge quasar catalog (1993). It has redshift $z = 2.10$. We found the other four objects all to be quasars. Their redshifts are listed in the following Table 1.

We would like to thank E. Margaret Burbidge for allowing us to quote her measures with the 3 meter reflector at Lick Observatory. For the last two quasars in Table 1 she reports independently measured redshift values of $z = 0.68$ and 0.33 (private communication).

1. Decreasing redshift as the quasars increase their distance from the galaxy

It is of interest to note that for these 5 quasars we find there is a very good linear correlation between redshift z and θ , the angular distance from the center of NGC 3516.

The statistical analyses show that the linear regression is $z=3.06 - 0.22\theta$, with the correlation coefficient $= -0.957$ and the standard error of the regression line $(S_y/x) = 0.23$. We note also that along the NW–SE alignment of these quasars, at $\theta \sim 22.5'$ there is a very strong X-ray source which is listed as having a Seyfert spectrum (Véron and Véron 1996) with redshift $z = 0.089$ (about 10 times the redshift of NGC3516). Optically it is a compact, semi-stellar object. With its strong X-ray and radio properties it is closely allied to BL Lac objects and therefore to the transition between quasars and objects with increasing amount of stellar population. When we consider these objects together, in Fig.2 we plot redshift z against the natural logarithm of θ , and find there is a good correlation: $z = 3.86 - 1.28 \ln \theta$. The correlation coefficient $= -0.942$ and the standard error of the regression line is 0.276. If these quasars were ejected from the central galaxy, it means that the younger the quasar, the closer it is to the center, and the higher the redshift.

EDITOR: PLACE FIGURE 2 HERE.

2. Alignment along galaxy minor axis

It is shown in Fig.3 that these 5 quasars and the X-ray Seyfert galaxy in the center of the field lie within ± 20 degree of a line which is the minor axis of NGC3516. Just the chance that the above 6 objects could accidentally lie within $\pm 20^\circ$ of a line through the center of the galaxy is, by itself, only 10^{-4} . But it is now clear that Seyfert galaxies eject quasars preferentially along their minor axes (see Arp 1997b,c). The NGC3516 line of

quasars turns out to lie within a few degrees of its minor axis. Therefore the chance of accidental occurrence is about another two orders of magnitude less.

EDITOR: PLACE FIGURE 3 HERE.

3. Quantization of redshifts

An especially significant result for these six objects is their specific values of redshifts. It has been known for a long time that the redshifts of quasars have preferred values at $z = 0.06, 0.30, 0.60, 0.96, 1.41$ and 1.96 and that these redshift peaks fit the formula $\Delta \ln(1 + z) = 0.206$.

The fit to the formula is given by Karlsson (1977). Some claims that the periodicity was a selection effect of redshifting emission lines through UBV filters has been refuted by showing the effect is not large enough to be significant and, more directly, by finding the same strong periodicity in quasars which had been identified from their radio emission (Arp et al 1990). It has also been shown that modern detectors give full wavelength coverage of the spectra without gaps (Burbidge 1978). And, of course, the present measures in NGC3516 represent a complete sample of the brightest candidates which have been selected by X-rays.

As was pointed out by Zhu and Chu (1990), this periodicity in redshift is clearer for multiple quasars which are associated with low redshift galaxies. Here we find that the 5 aligned quasars plus the quasarlike Seyfert have redshift values very close to these peaks:

S1102+7246 $z=0.09 \rightarrow 0.06$

Q1108+7226 $z=0.33 \rightarrow 0.3$

Q1106+7244 $z=0.69 \rightarrow 0.6$

Q1105+7242 $z=0.93 \rightarrow 0.96$

Q1105+7238 $z=1.40 \rightarrow 1.41$

Q1107+7232 $z=2.10 \rightarrow 1.96$

Considering that quasars in general usually define broader peaks, the quasars in this field are a particularly strong confirmation of this property which is so difficult to interpret as a Doppler induced redshift.

4. Summary

All of the properties of the high redshift X-ray objects in the NGC 3516 field confirm the body of earlier results on quasars associated with active galaxies. We conclude that because of the number of objects in this one group, the evidence has been greatly strengthened that quasars are ejected from nearby active galaxies and exhibit intrinsic redshifts.

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Fig. 1.— The ROSAT PSPC map of NGC3516. The five quasars are identified by their X-ray count rate C ($C=\text{cts}\cdot\text{ks}$ in 0.5–2.0 Kev band). Coordinate scales are in pixels = 1/2 arc sec.

Fig. 2.— The redshifts z plotted against natural logarithms of θ , the angular distance from central galaxy NGC3516. The line represents the linear regression.

Fig. 3.— The six objects which are brightest in X-rays in the NGC3516 field. Redshifts are written to the upper right of each object. The redshift of NGC 3516 is $z=0.009$.

Table 1.

QSO	Line	λ_{obs}	z
Q1105+7242	CIII] 1909	3658	0.916
(C=4.4)	MgII 2798	5428	0.940
	H_γ 4340	8391	0.932
			mean z=0.929
Q1105+7238	CIV 1549	3727	1.406
(C=3.1)	CIII] 1909	4569	1.393
	MgII 2798	6706	1.397
			mean z=1.399
Q1106+7244	MgII 2798	4729	0.690
(C=6.6N)	H_δ 4102	6944	0.693
	H_γ 4340	7324	0.688
	H_β 4861	8210	0.689
			mean z=0.690
Q1108+7226	MgII 2798	3702	0.323
(C=6.6S)	H_β 4861	6468	0.330
	[OIII] 5007	6659	0.329
	H_α 6563	8734	0.331
			mean z=0.328

Table 2.

Object	Redshift	Distance from NGC3516
	z	θ (arcmin)
Q 1107+7232	2.1	4.34
Q 1105+7238	1.4	7.42
Q 1105+7242	0.93	10.99
Q 1106+7244	0.69	10.37
Q 1108+7226	0.33	11.23

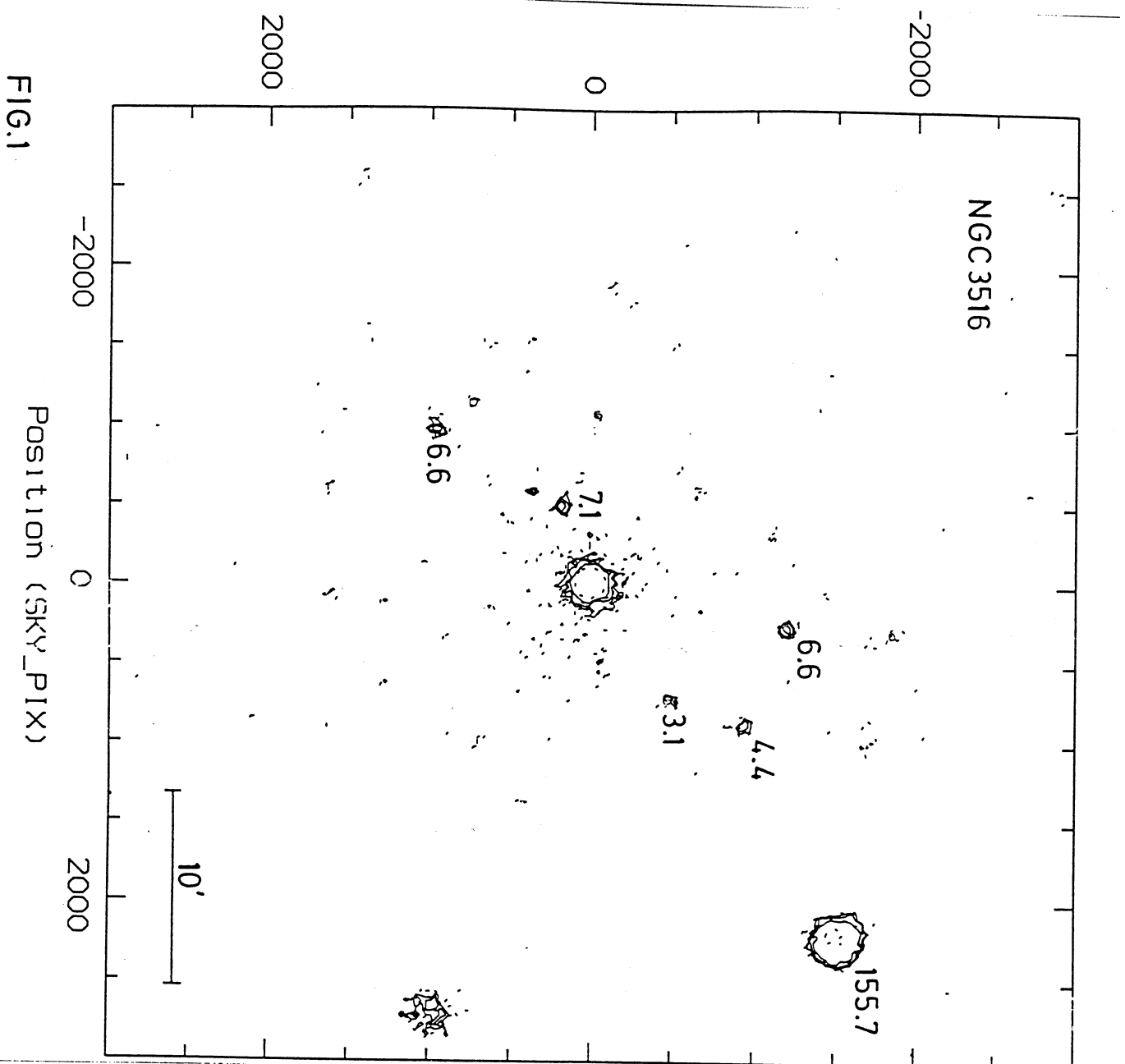


FIG.1

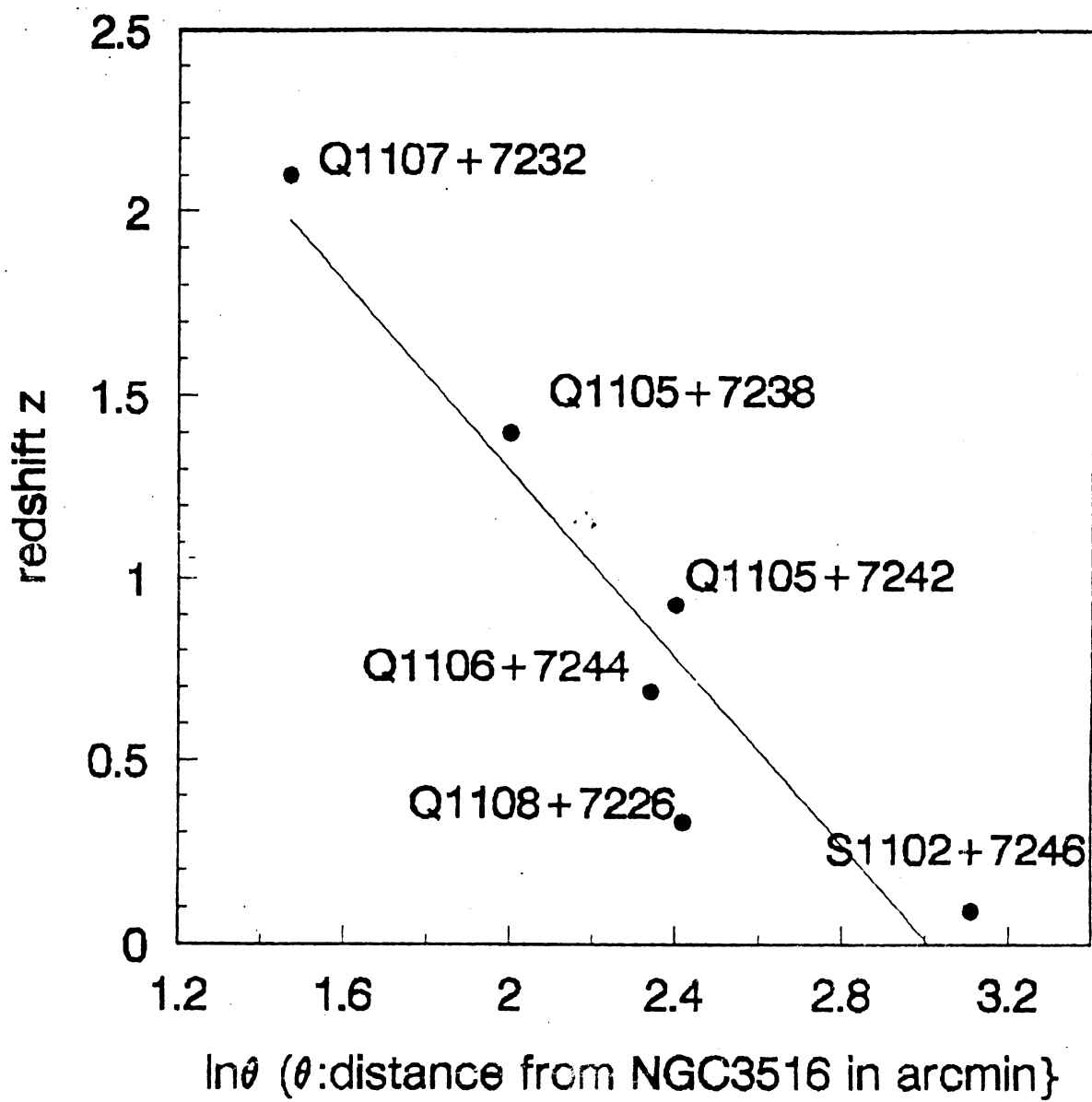


Fig 2.

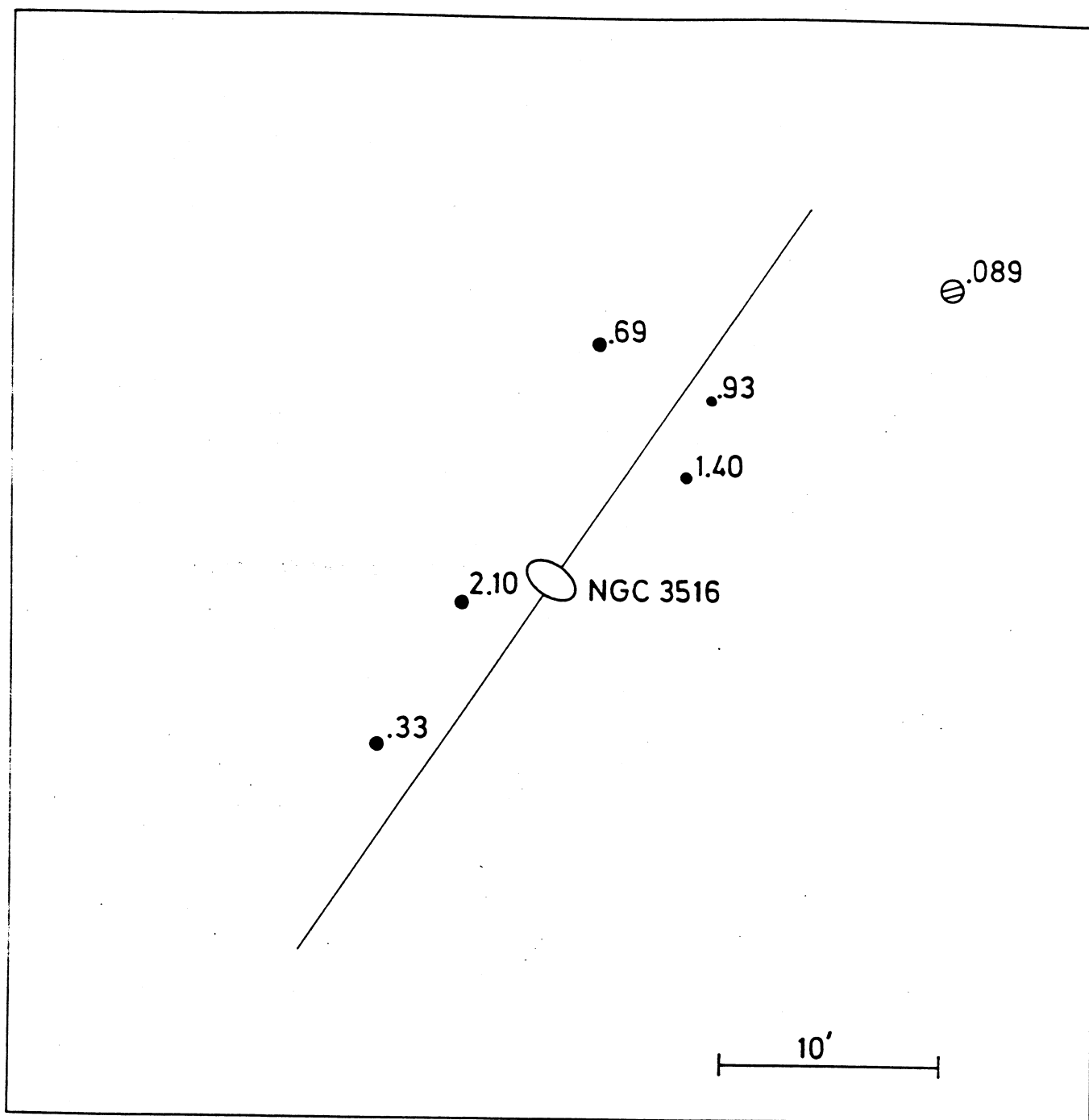


FIG. 3